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(71) Applicant: **AIRSEP CORPORATION** [US/US]; 401  
Creekside Drive, Buffalo, NY 14228-2070 (US).

(72) Inventors: **MCCOMBS, Norman, R.**; 109 Millwood  
Drive, Tonawanda, NY 14150 (US). **ALESSI, James,**  
A.; 4849 Gothic Hill Road, Lockport, NY 14094 (US).  
**CASEY, Robert, E.**; 649 W. Ferry Street, Buffalo, NY  
14222 (US).

(74) Agent: **KAREKEN, Ronald, S.**; Jaeckle Fleischmann &  
Mugel, LLP, 39 State Street, Suite 200, Rochester, NY  
14614-1310 (US).

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(54) Title: REDUCED NOISE OXYGEN CONCENTRATOR

(57) Abstract: A pressure swing adsorption apparatus for producing a gas mixture with a higher concentration of a particular gas such as oxygen from ambient air, in which the noisier components of the apparatus are contained in an internal removable module that is separated by sound insulation from the balance the apparatus to attenuate structure borne vibration, reduce radiated noise, and to absorb airborne sound.

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## **REDUCED NOISE OXYGEN CONCENTRATOR**

### **CROSS REFERENCE TO RELATED APPLICATIONS**

This application claims priority from a Provisional Patent Application, Serial No. 60/375,256, filed April 24, 2002.

### **FIELD OF THE INVENTION**

The present invention relates generally to an oxygen concentration apparatus, and more particularly to the concentration of oxygen by pressure swing adsorption.

### **BACKGROUND OF THE INVENTION**

Various types of equipment are known to provide patients with oxygen or oxygen-enriched air supplies in order to sustain life-support systems or relieve symptoms of various types of debilitating diseases, particularly of the lungs. In the past, pure oxygen or oxygen-enriched gases supplied from pressurized cylinders have been used. However, such cylinders are cumbersome and have a relatively short life before they need to be refilled or replaced. Oxygen concentrators using the principle of pressure swing adsorption were designed to overcome these obstacles.

Generally, the pressure swing adsorption technique, hereinafter referred to as PSA, is used to concentrate a selected gas out of a mixture of gases. Particularly, the oxygen concentrator is a device used to concentrate oxygen out of ambient air and to supply the oxygen concentrated mixture for medical or other purposes, where an oxygen rich gas is required. The general type and operating principles of PSA apparatus with which this invention is concerned are described in U.S. Patents 3,564,816; 3,636,679;

3,717,974; 4,802,899; 5,531,807 and 5,871,564, among others. For example, a pressure swing adsorption apparatus may include one or more adsorbers, each having a fixed sieve bed of adsorbent material to fractionate at least one constituent gas from a gaseous mixture by adsorption into the bed, when the gaseous mixture from a feed stream is sequentially directed through the adsorbers in a co-current direction. While one adsorber performs adsorption, another adsorber is simultaneously purged of its adsorbed constituent gas by part of the product gas that is withdrawn from the first or producing adsorber and directed through the other adsorber in a counter-current direction. Once the other adsorber is purged, the feed stream at a preset time is then directed to the other adsorber in the co-current direction, so that the other adsorber performs adsorption. The first adsorber then is purged either simultaneously, or in another timed sequence if there are more than two adsorbers, all of which will be understood from a reading of the above described patents. While oxygen concentrators have proven to be very useful for many medical and other applications, those known to us will generate a noise level that can limit their usefulness in many environments, such as public locations or at health treatment facilities.

Additionally, the compact size of this device requires internal components to be tightly packed and in close proximity of each other. While the compact size of the device gives the apparatus a distinct advantage, difficulty may be experienced in repair or maintenance. Removal or repair of a particular component often requires the removal of surrounding components so that access may be obtained.

Therefore, what is needed in the art is a compact and mobile oxygen

concentrator with reduced noise.

Furthermore, what is needed in the art is an oxygen concentrator with easily accessible components to assist in maintenance and repair.

### **SUMMARY OF THE INVENTION**

The present invention provides a new and improved pressure swing adsorption ("PSA" or "oxygen concentrator") apparatus that can operate at a lower noise level than prior art oxygen concentrators and facilitates access to internal components. This is accomplished by a unique configuration of internal components combined with strategic placement of sound deadening material. The prior art oxygen concentrators as known to us operate, for example, at noise levels of between about 48 and 54 decibels. The oxygen concentrator of the present invention will operate at a significantly lower noise level of about 38 decibels, and even lower. This improvement is accomplished by the strategic placement of noise absorbing material and rearrangement of the physical layout of the major noise-generating components in a removable module within the overall housing or cabinet of the PSA apparatus. The removable module serves as an advantage during maintenance and repair because all major components thus become easily accessible upon removal of the module. Also, from a manufacturing standpoint, the component assembly and receiving cabinet can be standardized, such that multiple models can be furnished to meet customer demand through the substitution of various module assemblies.

The module assembly contains virtually all of the noisier items of a PSA apparatus, including the air flow generating fan, the resonator and compressor used to intake air to be fractionated, the valves controlling the

gas flow through the adsorber beds, and the exhaust muffler. The noise reducing qualities of this device are further enhanced by the addition of at least one layer of sound absorbing material positioned between the outer walls of the module and the adjacent walls of the outer housing and internal components not contained within the module. This sound absorbing material will attenuate structure borne vibration, reducing radiated noise, as well as absorb airborne sound.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become apparent and be more completely understood by reference to the following description of a preferred embodiment of the invention when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic illustration of a combined PSA apparatus according to the invention;

Fig.2 is a front view of the reduced noise oxygen concentrator with the front panel of component module assembly removed.

Fig. 3 is a back view of the reduced noise oxygen concentrator with its back cover removed.

Fig.4 is an isometric view of the component module assembly from the front and top, without the noise reducing material.

Fig.5a and Fig.5b are detailed drawings of the fan mounted to the fan assembly panel.

Fig. 6 is a side view of the component module assembly with side cover removed.

Corresponding reference characters indicate corresponding parts throughout the several views. Although a preferred embodiment is illustrated and described, it is not to be construed as limiting the scope of the invention in any manner.

### DETAILED DESCRIPTION OF INVENTION

Turning now to the drawings and in accordance with the present invention, there is shown a specific embodiment, generally indicated as **20**, of a pressure swing adsorption apparatus, used for fractionating at least one component, namely nitrogen, from a gaseous mixture, generally but not necessarily ambient air, by pressure swing adsorption to produce a product gas. Although the invention as described uses two nitrogen adsorbers, it may also be incorporated into PSA apparatus using one or more than two adsorbers.

With reference to **Fig. 1**, ambient air is supplied to the PSA apparatus **20** through a filtered intake **21** and an intake resonator **22** to decrease the noise from the intake of the ambient air feed stream. The feed stream continues from resonator **22** and is moved from its outlet **22a** by a feed air compressor/heat exchanger assembly **24** alternatively to first and second adsorbers **30**, **32** through feed valves **40** and **42** respectively. Compressor/heat exchanger assembly **24** as shown includes a compressor **24a** with an air inlet **24c** and an outlet **24d** followed by the heat exchanger **24b**.

Ambient air is supplied to the apparatus **20** by a fan **63** used to draw air into the interior of the apparatus **20**, a portion of which air is drawn into the filtered intake **21** and the majority of which is directed throughout the interior

of the apparatus to cool the operating components.

When the feed stream alternatively enters inlets **30a**, **32a** of adsorbers **30**, **32** in a co-current direction, the respective adsorber fractionates the feed stream into the desired concentration of product gas. The adsorbent material used for the beds to separate nitrogen from the ambient air may be a synthetic zeolite or other known adsorber material having equivalent properties.

The substantial or usable portion of the oxygen enriched product gas generated by the ambient air flowing in the co-current direction sequentially in each one of the absorbers **30**, **32** is directed through the outlet **30b**, **32b** and check valve **34**, **36** of the corresponding adsorber to a product manifold **48** from where it is delivered to a mixing tank **56**. From mixing tank **56**, the product gas is delivered through a bacteria filter **57** to a user outlet at a regulated pressure and flow rate as determined by a flow controller **59** and a pressure regulator **58**. The balance of the product gas generated by each adsorber is timed to be diverted through a purge orifice **50** and a properly timed equalization valve **52** and an optional flow restrictor **53** to flow through the other adsorber **30** or **32** in the counter-current direction from the respective outlet **30b**, **32b** and to the respective inlet **30a**, **32a** of the other adsorber to purge the adsorbed, primarily nitrogen, gases. The counter-current product gas and purged gases then are discharged to the atmosphere from the adsorbers through properly timed waste valves **44**, **46**, tubing **47** and a sound absorbing muffler **48**.

As the principal noise generating components are the fan **63**, intake resonator **22**, the compressor/heat exchanger assembly **24**, the feed and

waste valves **40, 42, 44, 46**, and sound absorbing muffler **48**, these components according to the invention are mounted in a separate, removable module assembly **60** as will be described.

Referring now to **Fig. 2**, a front view of the reduced noise oxygen concentrator **20** is shown. The operating components of the apparatus are enclosed within an outer housing or cabinet **25**, the front cover of which has been removed from this view to illustrate component module assembly **60**. Attached to the outer surface of the module side walls **61** at both sides and the top wall **69** is a layer of sound deadening material **74**. Also shown in **Fig. 2** is a fan assembly panel **66**. Additionally, a layer of sound deadening material is shown to be attached to the inner surface of the back wall **67** of the cabinet superstructure (not shown), where the outer surface of the back wall **67** of the module assembly **60** meets the inner surface of the back wall.

Referring again to **Fig. 2**, the working components shown to be mounted on the front side of the concentrator **20** within module **60** include intake resonator **22**, fan **63**, a valve block **64** forming the feed and waste valves **40, 42, 44, 46**, and waste muffler **48**. The working components of the back side of the concentrator as illustrated in **Fig. 3** and partially in **Fig. 2** include the pair of adsorbers **30** and **32**, equalization valve **52**, a circuit board **70** containing the electronic components that control the operating sequence of the apparatus **20**, and compressor assembly **24**. The compressor **24** is mounted to the bottom wall **62** of module **60** by means of the appropriate screws or other suitable fastening devices.

The valve block **64**, as shown in **Fig. 2** and **Fig. 3**, is disposed within



module **60** immediately below and in front of the compressor assembly **24**.

The valve block **64** may suitably be attached to bottom wall **62** by means of a quick release fastener, such as Velcro™. The feed valves **30a**, **32a** are in the flow path between the heat exchanger **24b** and the adsorber inlets **30a**, **32a** by suitable tubing which at **71** and **72** are connected by detachable couplings to enable removal of the module **60**. Although not illustrated, the electrical connections between the operating components within the module **60** on the one hand, and the power source and circuit board **70** on the other hand, also are made by detachable bus connections in a manner well known in the art.

Immediately above the bottom wall **62** of module **60** is the intake resonator **22**. The intake resonator **22**, as shown in Fig. 5, is mounted in close proximity to fan **63** to receive through filtered intake **21** (not shown) the portion of air to be fractionated. Ambient air is drawn into housing **25** by a suitable louvered opening (not shown) in the rear wall **67** of housing **25**.

The upper wall **69** of component module assembly **60** has an opening **65** coinciding with the internal fan panel **66**. The fan panel **66** is mounted at about a 20° angle so that fan **63** draws air from inside housing **25** into the component module assembly **60** to be directed partially into intake **21** and the balance over the operating components within module **60** before exiting through an opening at the back wall of module **60**.

In furtherance of this objective the fan and compressor have been repositioned within the walls of the module to further reduce the noise level. This is accomplished by positioning the compressor substantially toward the back wall, opposing the fan panel **66**.

**Fig. 4** further illustrates the opening **65** in the top of the module **60** adjacent to the fan **63**. **Fig. 5a** and **Fig. 5b** provide two views of the fan **63** and fan panel **66** and further illustrate the means and angle by which fan **63** mounted to the fan panel **66**. **Fig. 5b** further illustrates a layer of sound absorbing material **75** between the fan assembly panel **66** and the fan **63**. The fan assembly panel **66** is then mounted between the sidewalls, angularly facing the opening in the upper wall. The noise reducing qualities of this device are further enhanced by the addition of a layer of sound absorbing material **75**. This sound absorbing material will attenuate structure borne vibration and reduce radiated noise. Suitable openings (not shown) are provided in the modules walls, as for example bottom wall **62** and back wall **67** of the component module assembly **60** where the circulating air cooling the contained components and the waste gas from muffler **48** exit the component module assembly.

**Fig. 6** is a the side view of the component module assembly with side cover removed. The figure particularly illustrates a compressor **24** mounted in close proximity to the back wall **67** of the component module assembly. The figure also illustrates a side view of the fan panel **66**, mounted in close proximity to the front wall **68** of the component module assembly. Sounds normally associated with the discharging of a pressurized stream of gas to the atmosphere are muffled by the silencer **48**.

While this invention has been described as having a particular design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the present invention using the general principles

disclosed herein. Further, this application is intended to cover such departures from the present disclosure as come within the known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

## CLAIMS

1. A pressure swing adsorption apparatus having operating components for producing a concentration of oxygen or other gas from a gas mixture such as ambient air, the apparatus comprising an housing containing the operating components and a component module assembly positioned within said housing, the component module assembly containing selected ones of the operating components and removably mounted within the housing.

2. The apparatus of claim 1, in which the selected ones of the operating components comprise those components generating higher levels of noise during operation.

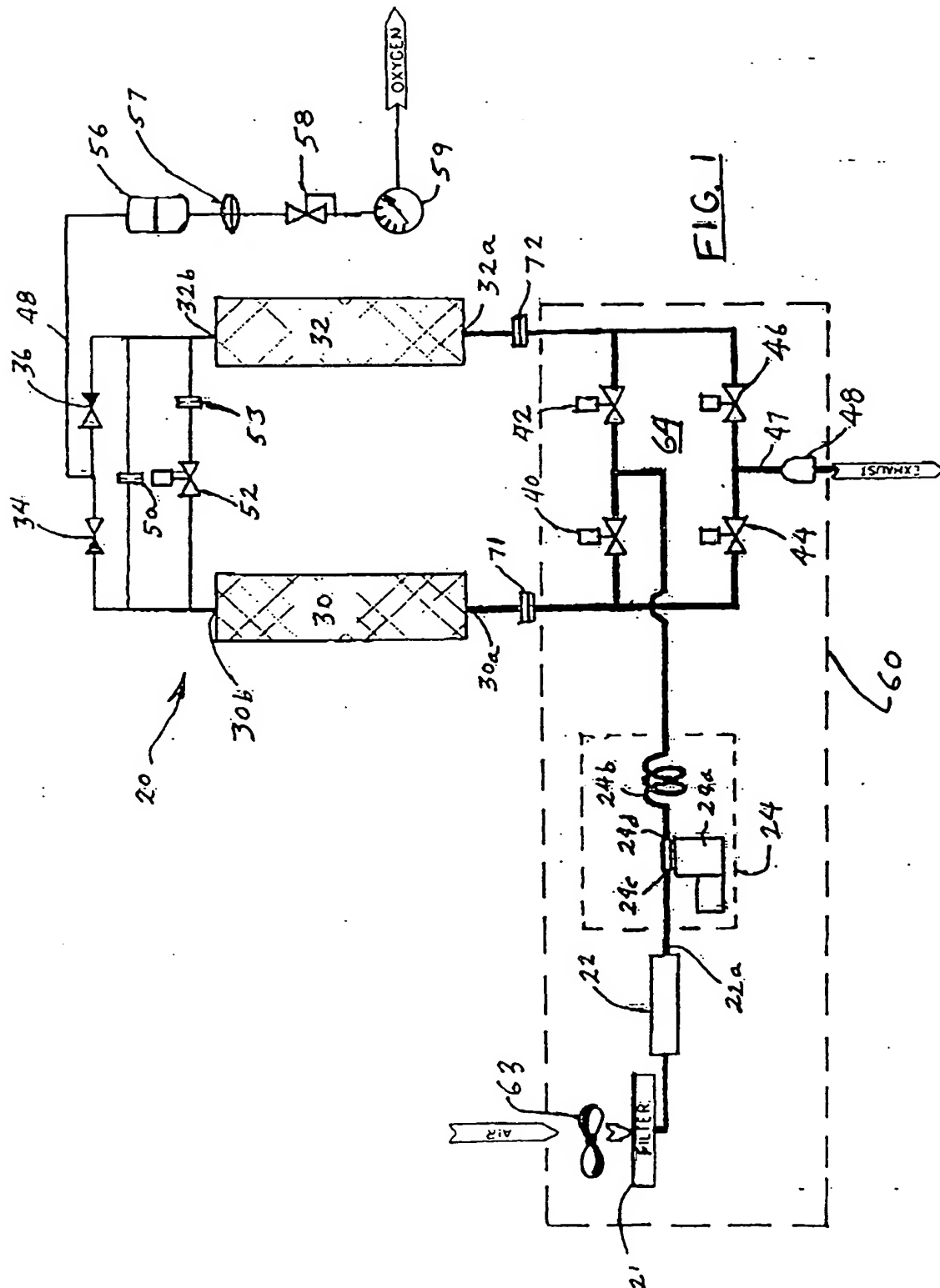
3. The apparatus of claim 2 in which one of the selected components comprises a blower fan to draw the gas mixture into the module assembly and the module assembly includes wall means defining an opening in fluid communication with the blower fan.

4. The apparatus of claim 3 wherein others of the selected components comprise an intake resonator, a gas compressor, operating valves and an exhaust muffler, and the wall means further defines an opening to exhaust the portion of the gas mixture not forming part of the concentration of oxygen or other gas.

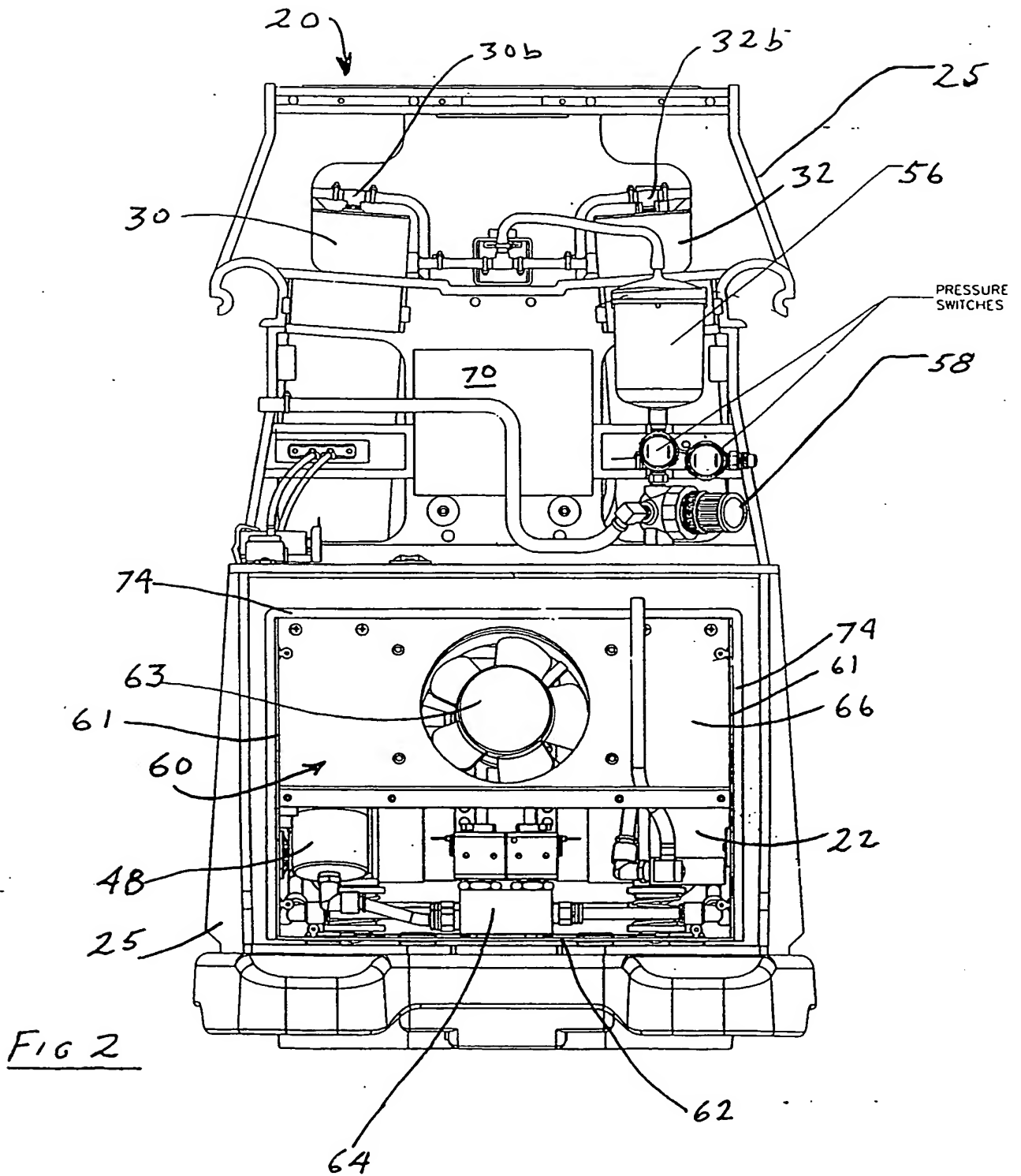
5. The apparatus of claim 3 in which the blower fan is affixed to the wall means, and further comprising a layer of sound and vibration absorbing material mounted between the blower fan and the wall means.

6. The apparatus of claim 2 wherein the module assembly comprises top, bottom, front, back and side walls enclosing the selected operating

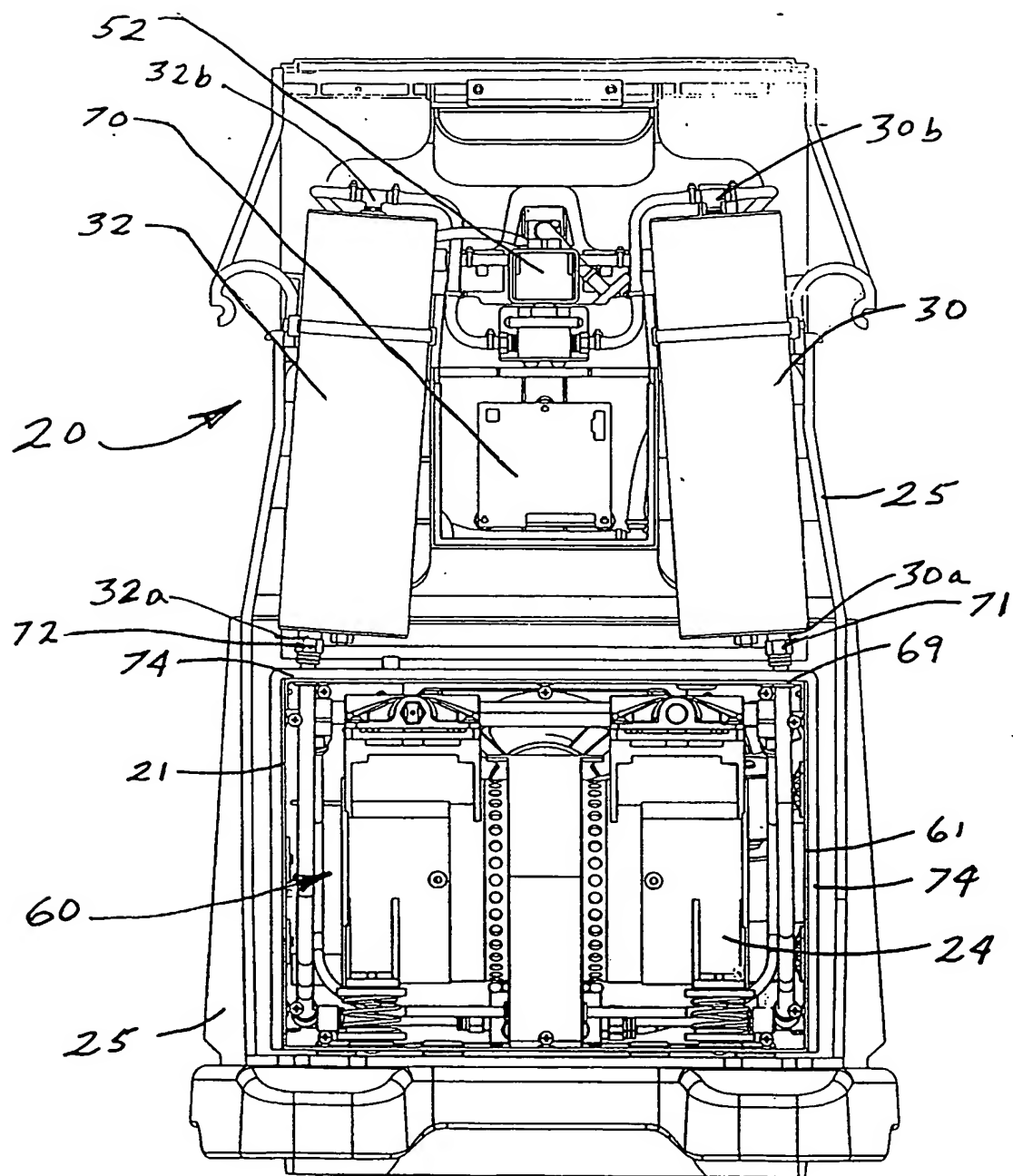
components, and further comprising at least one layer of sound absorbing material covering the outer surface of at least the top, front and side walls.



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FIG. 3



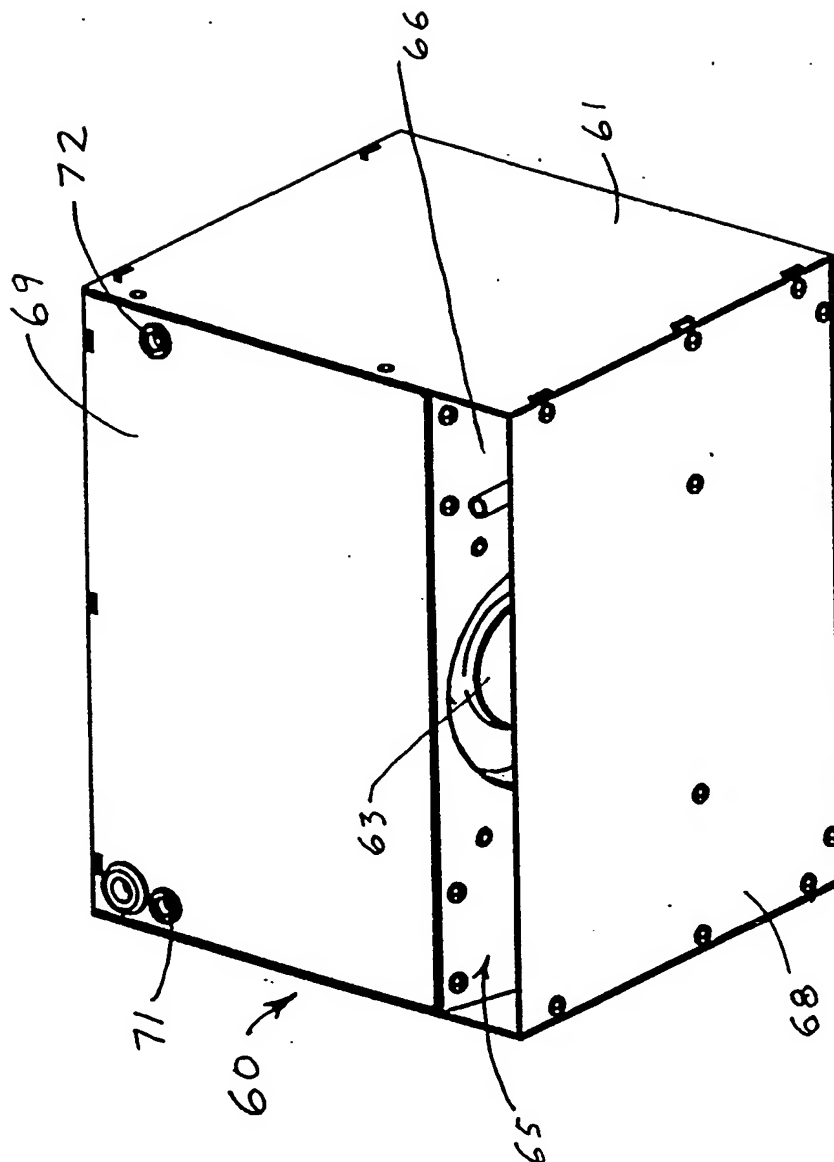
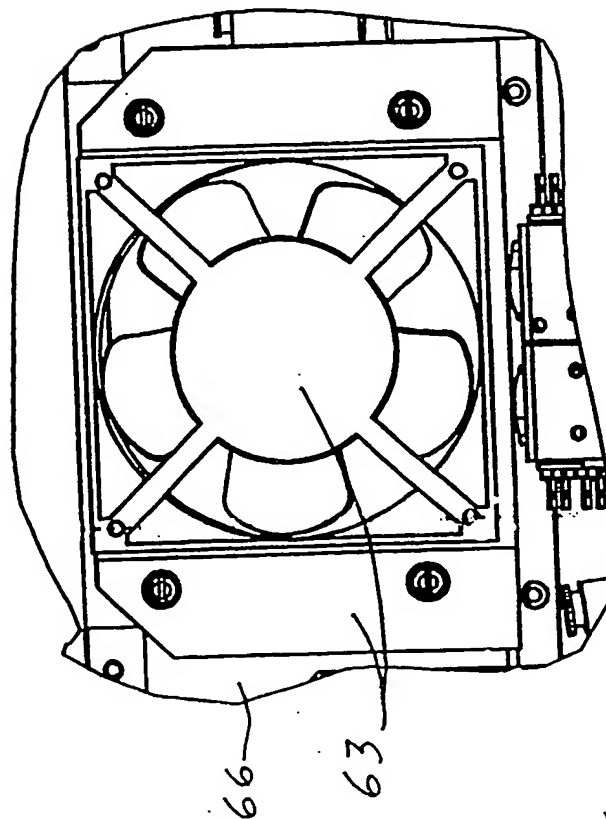
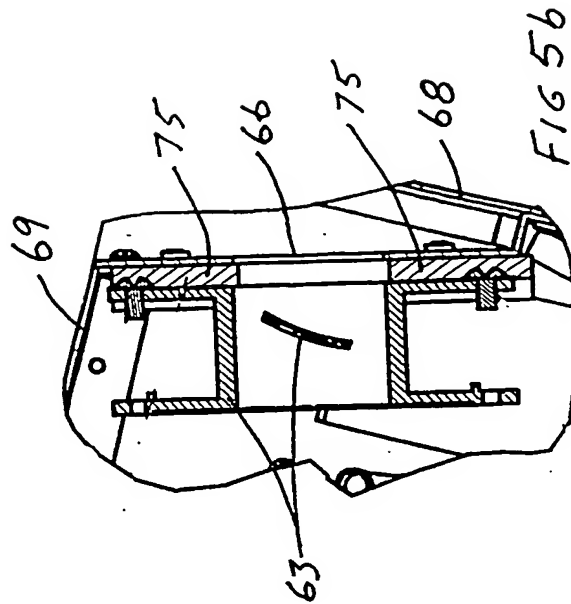
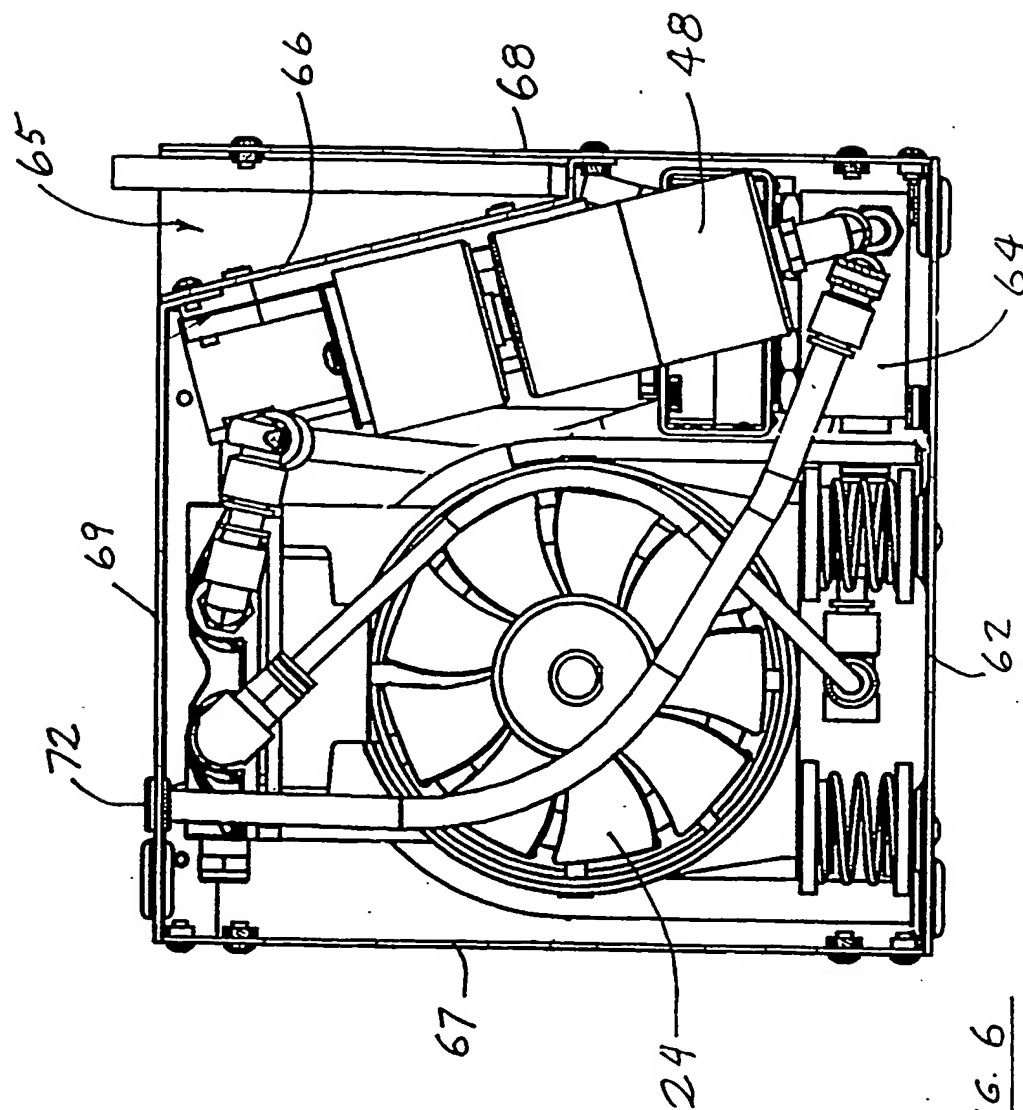


FIG. 4

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FIG. 6

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/12470

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B01D 53/047  
US CL : 96/128,130,140

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 96/121,126-128,130,134,136,139-143

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
NONE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,584,001 A (DECHENE) 22 April 1986 (22.04.86) Figs. 1 and 3, and col. 2, line 22- col. 6, line 31.	1-2
Y		3-6
Y	US 5,871,564 A (MCCOMBS) 16 February 1999 (16.02.99) col. 5, lines 40-47.	3-5
Y	US 4,511,377 A (MCCOMBS) 16 April 1985 (16.04.85) Fig. 1 and col. 2, lines 50-53.	6
A	US 3,543,482 A (FOSTER) 01 December 1970 (01.12.70).	1-6
A	US 4,302,224 A (MCCOMBS et al.) 24 November 1981 (24.11.81).	1-6
A	US 4,378,982 A (MCCOMBS) 05 April 1983 (05.04.83).	1-6
A	US 4,802,899 A (VRANA et al.) 07 February 1989 (07.02.89).	1-6
A	US 4,826,510 A (MCCOMBS) 02 May 1989 (02.05.89).	1-6

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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## INTERNATIONAL SEARCH REPORT

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## C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,971,609 A (PAWLOS) 20 November 1990 (20.11.90).	1-6
A	US 5,474,595 A (MCCOMBS) 12 December 1995 (12.12.95).	1-6
A	US 5,531,807 A (MCCOMBS) 02 July 1996 (02.07.96).	1-6

Form PCT/ISA/210 (second sheet) (July 1998)